

Haimeng Zhao

Email: haimengzhao@icloud.com
GitHub: github.com/haimengzhao
Website: hmzhao.me, Google Scholar

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EDUCATION

- Tsinghua University** Beijing, China
B.Sc. in Physics & Maths, Minor in Statistics, Advisor: *Dongling Deng, Wei Zhu* 2020–2024(Expected)
GPA: **3.96/4.00**, Major GPA: **4/4**, Rank: **1/100**; English: TOEFL 113/120 (25/Speaking), GRE 335/340
- EPFL (École Polytechnique Fédérale de Lausanne)** Lausanne, Switzerland
Exchange, GPA: **6/6** (4 grad courses), Advisor: *Giuseppe Carleo & Filippo Vicentini* 2022 Fall
- California Institute of Technology** Pasadena, CA, USA
Undergrad Research Fellow @ IQIM, Advisor: *John Preskill & Matthias Caro* 2023 - Now

RESEARCH INTEREST

- *How to better understand the universe, and how is understanding even possible?*
- Quantum Information, Statistics & Learning Theory
- AI for Science, especially Physics & Astrophysics
- Quantum Many-body Physics: Theory & Computation
- Generative Learning, Neural Differential Equations

SKILLS

- **Computational Physics:** (Quantum) Monte Carlo, DFT, Tensor Network, Neural Quantum States. NetKet and NASA EMAC contributor.
- **(Quantum) Machine Learning:** (Quantum) Learning Theory, Variational Quantum Algorithms, Generative Learning, Neural Differential Equations.
- **Programming:** High performance scientific computing with Python & C++. Differentiable programming with JAX, PyTorch (6 years) & TensorFlow.

SELECTED PUBLICATIONS

- ¹**Haimeng Zhao**, Laura Lewis, Ishaan Kannan, Yihui Quek, Hsin-Yuan Huang, and Matthias Caro, “Learning Quantum States and Unitaries of Bounded Gate Complexity”, (2023), submitted for QIP 2024.
- ²**Haimeng Zhao**, Giuseppe Carleo, and Filippo Vicentini, “Empirical Sample Complexity of Neural Network Mixed State Reconstruction”, (2023), arXiv:2307.01840, under review for Quantum.
- ³**Haimeng Zhao**, “Non-IID Quantum Federated Learning with One-shot Communication Complexity”, Quantum Machine Intelligence **5**, 3 (2023), arXiv:2209.00768, short talk at QTML 2023 (acceptance rate 8%).
- ⁴**Haimeng Zhao** and Wei Zhu, “MAGIC: Microlensing Analysis Guided by Intelligent Computation”, The Astronomical Journal **164**, 192 (2022), arXiv:2206.08199.
- ⁵**Haimeng Zhao** and Wei Zhu, “Parameter Estimation in Realistic Binary Microlensing Light Curves with Neural Controlled Differential Equation”, ICML Workshop on Machine Learning for Astrophysics (2022).
- ⁶Junyi Liu, Yifu Tang, **Haimeng Zhao**, Fangyu Li, and Jingyi Zhang, “CPS Attack Detection under Limited Local Information in Cyber Security: An Ensemble Multi-Node Multi-Class Classification Approach”, ACM Transactions on Sensor Networks (2023), arXiv:2209.00170.

SELECTED RESEARCH EXPERIENCE

- The Complexity of Learning Physical Systems, Evolution, and Functions** Feb. 2023 - Now
Advisor: *John Preskill, Matthias Caro, Hsin-Yuan Huang, IQIM @ Caltech* **First Author [1]**

- Rigorously proved $\tilde{\Theta}(G)$ sample complexity of learning states and unitaries with circuit complexity G .
- Established an exponential separation between average-case and worst-case unitary learning.
- Disproved existence of computationally efficient learners for poly complexity states and unitaries.
- Formulated a unifying information-theoretic perspective on the quantum no free lunch theorem.
- Proved that certain nice functions cannot be efficiently implemented or learned by quantum experiments.

• **AI4Q: Sample Complexity of Neural Quantum State Tomography** Aug. 2022 - Jul. 2023

Advisor: Giuseppe Carleo & Filippo Vicentini, Computational Quantum Science Lab @ EPFL **First Author [2]**

- Introduced control variates to control gradient variance and significantly reduce sample complexity.
- Conducted extensive numerical & theoretical studies to understand different sample complexity behavior.
- Benchmarked different tomography methods and propose to design quantum-resource-efficient NQSSs.

• **AI4Astro: ML Framework for Realistic Microlensing Event Analysis** Oct. 2021 - Sep. 2022

Advisor: Wei Zhu, Department of Astronomy @ Tsinghua **First Author [4, 5]**

- Introduced U-Net and neural controlled differential equations to parameter estimation of microlensing.
- Developed a machine learning framework for irregular astronomical time series, listed on NASA EMAC.
- Accelerate microlensing analysis by $\times 10^5$ and successfully applied to real events for the first time.

• **QAI: Non-IID Quantum Federated Learning** Jul. 2022 - Sep. 2022

Single authored work. Extending [6] to the quantum regime. **Single Author [3]**

- Proposed and studied the non-IID quagmire in quantum federated learning, theoretically & numerically.
- Extended [6] to a quantum algorithm. Conducted extensive numerics to show its robustness and efficiency.

SELECTED COURSEWORK

* for graduate courses. Self taught: Quantum Field Theory, Lattice Field Theory, Topology, Group Theory, Theoretical Computer Science, Quantum Information Theory.

High Dimensional Probability*	A	Quantum Artificial Intelligence*	A
Interacting Quantum Matter*	6/6	Stat. Phys. of Computation*	6/6
Information Theory and Coding*	6/6	Biophysics*	6/6
Computational Quantum Physics*	A+	Solid State Physics	A+
Atom and Molecule Physics	A	General Relativity	A
Analytical Mechanics	A	Quantum Mechanics	A
Statistical Mechanics	A	Electrodynamics	A+
Complex Analysis	A+	Partial Differential Equations	A+

SCHOLARSHIPS AND AWARDS

- Caltech Summer Undergraduate Research Fellowship 2023
- National Scholarship (National Highest Honor for Undergrads) 2022
- Scholarship of the National Astronomical Observatory of China 2022
- Chi-sun Yeh Scholarship (Highest Honor for Physics Major), Tsinghua Xuetang Talents Program 2020–2022
- S.-T. Yau College Maths Contest, Silver Medal (2nd place) in Mathematical Physics 2022
- S.-T. Yau High School Science Award, Gold Medal (1st place) in Computer Science 2019
- National Awarding Program for Future Scientists, 1st place 2019
- Chinese Physics Olympiad, Bronze Medal 2019